

REMARKS

In the office action, the examiner makes the election/restriction requirement final. The applicant still disagrees with the restriction requirement, particularly now that the examiner has clarified the basis for the requirement. Accordingly, the next part of this response is a brief argument against the restriction requirement, it being believed that proper understanding of this issue is important to appreciate the invention and particularly to the rejoinder request made herein.

The examiner looks at the two flowcharts, Figs. 2 and 4, and sees the word *matrix* in Fig. 4, but not in Fig. 2, and concludes that the methods they represent are mutually exclusive species justifying a restriction order, with no comment made about the fact that claim 1 is presented by the applicant as a generic claim, with express argument presented to that effect in the response mailed April 5, 2007. The examiner's reasoning regarding the mutually exclusive notion is that "a discrete mathematical process such as a matrix is inherently not a continuous mathematical process," and the examiner finds (without explanation) that Fig. 2 "discloses a continuous method of processing seismic data."

To begin the applicant's response to this, matrices are merely mathematical notation for writing a single equation that represents many equations. An $M \times N$ matrix, such as the vibrator signature matrix S in equations (7) and (8) in the application, is no more inherently continuous or discontinuous than a 1×1 matrix. (Bold type is used in this letter to denote a matrix.) Taking matrix equation (8) as an example, it represents a system of M equations, the first of which is

$$S_{11}E_1 + S_{12}E_2 + \dots + S_{1N}E_N = D_1$$

whereas in a single vibrator example ($N = 1$), the system of equations would be the single equation

$$SE = D$$

The applicant is not sure what the examiner means by *continuous*, but the one equation is no more inherently continuous or discontinuous than any of the M equations. The matrix formalism is merely a compact notation for writing a system of two or more equations. (Actually, known matrix manipulation techniques, such as calculating the inverse of a matrix, make solution of the system of equations more

elegant and computationally efficient; but this does not add any discontinuous aspect to the method.)

Both Fig. 2 and Fig. 4 outline the same inventive method, which revolves around solving the matrix equation $F = I(S^{-1})$, which is equation (10) in the application, for the filter(s) F that are to be applied to the seismic data. Figure 2 represents the simpler case of a single vibrator (or multiple vibrators activated with a single, common sweep), and is discussed first in the application. Then, following a common pedagogical approach, the method is generalized. Figure 4 represents the method applied to the general case of N vibrators each radiating M sweeps into the earth. The general method of Fig. 4 reduces to the special case method of Fig. 2 for $M = N = 1$. Thus, they do not represent separate species lacking a generic method. Instead, Fig. 4 is the generic method for which Fig. 2 represents one of the species. There are minor differences between Figs. 2 and 4 in that Fig. 2 contains more detail (i.e., features present in some embodiments) such as steps 6 and 7, but these steps apply as well to Fig. 4 but for brevity are not repeated. Similarly, the iteration loop 11 may be applied also to Fig. 4, as stated in the sentence at lines 18-20 on page 22 of the PCT publication of the present application (WO 2004/095073). Likewise, the matrix inversion of step 60 in Fig. 4 reduces (for a 1x1 matrix) to simply “dividing [the desired impulse response] by the vibrator signature” as stated in step 8 of Fig. 2. Further, attention is directed in the present application to the first sentence just below equation (10) on page 22: “Note that equation (10)¹ is the matrix equivalent of equation (4) discussed above.” *Above* refers to the discussion of Fig. 2 where equation (4) is the equation used in the illustrative embodiment to calculate the deconvolution filter for the 1x1 case, but, as stated just above the equation, equation (4) follows from the more general matrix equation which is in fact equation (10).

Thus, the restriction order is based on a misunderstanding and oversimplification of the mathematical concepts and tools involved in the present inventive method. The restriction order should be withdrawn.

¹ The quoted text states the equation number as 1, but this is an obvious error. It should be 10, coming as it does immediately after equation (10). Also, equation (1) makes no sense in the context of the quoted sentence. A specification amendment is submitted herewith to correct this error.

§ 103 rejection of claim 1

Claim 1 is rejected as obvious in view of Trantham combined with Allen. In response, the applicant points particularly to step (c):

(c) specifying a desired seismic data processing impulse response, wherein the high and low frequency portions of an amplitude spectrum of said impulse response taper to zero at a rate faster than does the high and low frequency portions of an amplitude spectrum of said vibrator signature;

The examiner concludes, "By definition, an impulse response is instantaneous, therefore the high and low frequency portions of an impulse response will inherently taper to zero faster." The applicant responds as follows. An ideal impulse is indeed instantaneous. A practical impulse such as an explosive source is nearly instantaneous. But claim 1(c) speaks of the impulse response's *amplitude spectrum*. That is what must taper to zero faster than as specified in the claim. As the examiner will know from her knowledge of Fourier analysis, the spikier a function of time is (the mathematical limiting case is the Dirac delta function), the more terms (and frequencies) that are needed to represent it in its Fourier series expansion, i.e., in its *amplitude spectrum*. Attention is directed to the discussion in the paragraph on page 14 of the application beginning on line 3, where it is explained that a desired *amplitude spectrum* is first determined according to the teachings of the invention. Then, proceeding down through the following passages in the text, one comes to the sentence at lines 19-21 of page 15: "The zero phase impulse is computed by taking the inverse Fourier transform of the amplitude spectrum . . ." See also the sentence beginning at line 26 of page 14 stating "In addition, it is well known . . . that a square impulse response corresponds to a longer pulse," i.e. a square wave's Fourier expansion will require more frequencies to represent it.

Thus, it can be seen that the *amplitude spectrum* of a peaky impulse response cannot also be a narrow peaky function; in fact, just the opposite.

Now that step (c) of claim 1 has been explained as not merely reciting something that must always be true, i.e., step (c) cannot be dismissed as a mere

tautology as believed by the examiner, the applicants point to step (c) as being a meaningful and significant limitation that is not disclosed by either Trantham or Allen. Neither teaches that a desired impulse response should be specified using a criterion that its amplitude spectrum must "taper to zero at a rate faster than does [sic – should be *do*] the high and low frequency portions of an amplitude spectrum of said vibrator signature." Thus, the amplitude spectrum of the impulse response must be smaller than or equal to that of the vibrator signature at the low and high ends of the spectrum. The impulse response amplitude spectrum must therefore be compared to that of the vibrator signature and adjusted according. Different sweeps mean different impulse responses. An impulse response for the vibrator is the minimum phase (least delay) pulse with the same frequencies as in the sweep; it is not a spike (delta function), which would contain all frequencies.

Because step (c) is believed to be neither disclosed nor suggested in either Trantham or Allen, it follows that claim 1 and all its dependent claims are patentable over them. The applicant also points out that step (d) of independent claim 26, withdrawal of which is to be reviewed, is substantially the same as step (c) of claim 1, and therefore non-obvious over Trantham and Anderson as well.